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Cockpit development in the Crew integration & Automation Testbed advanced technology development program

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ABSTRACT

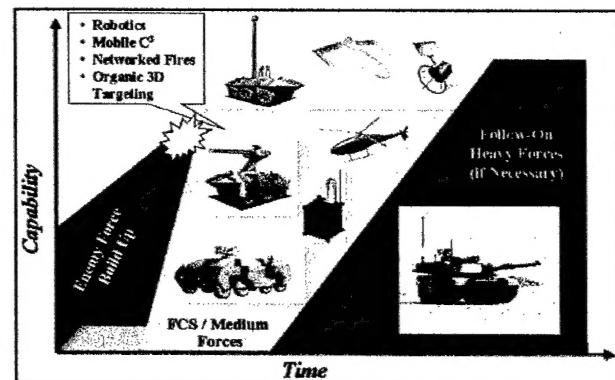
The US Army has been evolving advanced cockpit designs for future ground combat vehicles through a series of technology development programs that began in the early 1990s. The current effort, the Crew-integration & Automation Testbed (CAT) program, is focused on providing direct transition to the next generation of Army vehicles. This paper describes the cockpit concept, its evolution, and the experimentation plan..

Keywords: Keywords: cockpit, crew station, interface, crew reduction.

1. INTRODUCTION

The Chief of Staff of the Army has developed and published a vision to transform its forces to increase the Army's responsiveness. The Army Vision states that its "spectrum of likely operations describes a need for land forces in joint, combined, and multinational formations for a variety of missions extending from humanitarian assistance and disaster relief to peacekeeping and peacemaking to major theater wars, including conflicts involving the potential use of weapons of mass destruction. The Army will be responsive and dominant at every point on that spectrum. We will provide to the Nation an array of deployable, agile, versatile, lethal, survivable, and sustainable formations, which are affordable and capable of reversing the conditions of human suffering rapidly and resolving conflicts decisively."¹

The Army has partnered with the Defense Advanced Projects Agency (DARPA) to meet this requirement in the Future Combat Systems program. The program's goals are to improve land force lethality, protection, mobility, deployability, sustainability, and command and control capabilities. "The Future Combat Systems (FCS) program will develop network centric concepts for a multi-mission combat system that will be overwhelmingly lethal, strategically deployable, self-sustaining and highly survivable in combat through the use of an ensemble of manned and unmanned ground and air platforms. An FCS-equipped force will be capable of providing mobile -networked command, control, communication and computer (C4) functionalities; autonomous robotic systems; precision direct and indirect fires; airborne and ground organic sensor platforms; and precision, three-dimensional, air defense; non-lethal; adverse-weather reconnaissance, surveillance, targeting and acquisition (RSTA)."² The strategy is to quickly deploy a highly effective medium weight force and to follow with the heavy force only when required (Fig. 1).



Two aspects of this vision directly affect cockpit design. The first aspect is deployability. The Army Vision states a requirement "to put combat force anywhere in the world in 96 hours after liftoff - in brigade combat teams for both stability and support operations and for warfighting. We will build that capability into a momentum that generates a war-fighting division on the ground in 120 hours and five divisions in 30 days."¹ This requirement, combined with existing

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military transport capabilities, greatly limits the size and weight of any component of the force. The objective is for every FCS platform to be transported by C-130 Hercules cargo plane, which has a carrying capacity of less than 20 tons. This is in stark contrast to the Army's current main battle tank, the M1 Abrams, a system that is operated by four soldiers and which weighs approximately 70 tons. One opportunity to bridge this gap in requirements is to reduce the crew size from to two soldiers, which reduces the interior volume required in the vehicle. Besides making the vehicle smaller, volume reductions translate to a decreased armor, which results in significant weight savings.

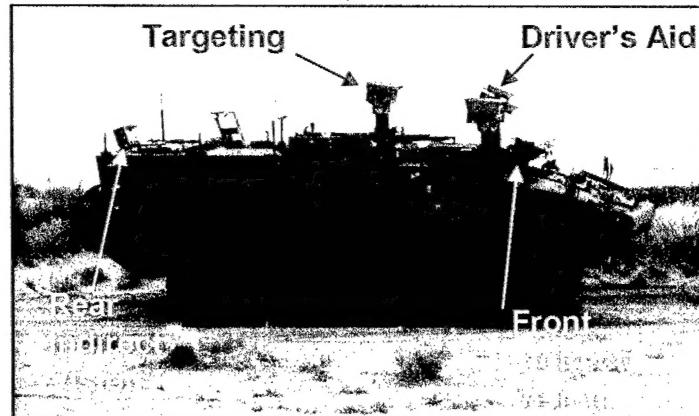
A second aspect of the vision that impacts cockpit design is the requirement to be multi-mission capable. This requirement impacts the payloads of the systems as well as the interfaces used to interact with the systems and their payloads. A common cockpit that provides equally effective performance for the fight, scout, and carrier missions greatly reduces the amount of training required for a multi-mission capable force.

To support this effort, the Army has focused a portion of its science and technology funds toward developing the cockpit technology required for FCS. The Army program is called the Crew integration & Automation Testbed. This paper describes the program, the evolution of its cockpit design, the cockpit itself, and the experimentation and demonstration schedule.

2. CREW INTEGRATION & AUTOMATION TESTBED ADVANCED TECHNOLOGY DEMONSTRATION PROGRAM

The Crew integration & Automation Testbed (CAT) Advanced Technology Demonstration (ATD) is a U. S. Army Tank Automotive Research, Development & Engineering Center (TARDEC) program focused on cockpit technology for FCS. The goal of the CAT ATD is to demonstrate a multi-mission capable two-man crew station concept, integrated into a C-130 transportable chassis. The program focuses on an improved soldier machine interface (SMI) and automated decision aids. Through the development, integration and experimentation of these advanced technologies, the program will demonstrate sufficient technology readiness to transition the technologies to the Future Combat Systems (FCS) program.

Specific technologies and engineering areas include; soldier machine interface design based on the Crewman's Associate program, indirect vision driving, speech recognition, three-dimensional audio, cognitive decision aids and task aids. The CAT ATD also hosts an embedded simulation system which allows virtual operation of the crew station as well as simulated training, mission planning and mission rehearsal. The SMI covers the fight, scout and carrier military operational specialties. In addition, the CAT SMI supports the command and control of unmanned systems operating in both semi-autonomous and teleoperation modes. The CAT ATD will demonstrate its two-crew concept in both front-to-back and side-by-side configurations within a Stryker platform that is C-130 transportable (Fig. 2).



3. EVOLUTION OF THE CREW STATION TECHNOLOGY BASELINE

The US Army has been evolving advanced cockpit concepts since the early 1990s. The initial concept was developed in the Crewman's Associate ATD. This two-man cockpit was developed by a team of government and contractor engineers, led by a team of human factors engineers with experience developing rotorcraft cockpits. The goal of the program was to develop an advanced cockpit for a future tank that could be fielded with technologies available in 2005. Key features of the cockpit were identical crew stations, center-mounted yoke, multi-function displays, indirect vision, speech recognition and three-dimensional audio. A simulator of the cockpit design was built using commercial

hardware and tested statically using active duty soldiers (Fig. 3). Test results from the Crewman's Associate experiments, both objective data collection and subjective comments from the soldier operators, validated key aspects of the design and the following design guidelines:

- All combat-critical functions must be located on the primary controller.
- All critical information must be located in the primary vision zone.
- Maximize one-step functions, i.e. single actuation to select target, slew gun, zoom image, perform 'friend or foe' query, and laser designate.
- Provide a consistent mental model amongst subsystems to reduce errors during high workload or high stress situations.

These key features and design guidelines were then carried forward to the Vetronics Technology Testbed (VTT) program. The goal of the VTT program was to test key features of the design in a real vehicle system. In support of the Future Scout and Calvary System program, the design was modified to meet the requirements of a scout mission as opposed to the Crewman's Associate tank mission. The size of the station components was restricted so that the stations could fit front-to-back or side-by-side within the back of a M2 Bradley armored fighting vehicle. The stations were implemented using commercial hardware, integrated into the vehicle, and tested using active duty soldiers at Camp Grayling Michigan (Fig. 4). Primary results from these tests were soldier feedback on the interfaces, assessment of workload for a 2-crew scout vehicle and baseline data for indirect vision driving.

The CAT ATD is building upon the successes and lessons learned of both the Crewman's Associate ATD and the Vetronics Technology Testbed programs to meet the objective of developing a two-man operable, multi-mission capable cockpit that can be integrated into a C-130 transportable combat system.

4. CAT ATD COCKPIT

The CAT ATD cockpit consists of two identical stations that were designed using the principles originally developed and validated in the Crewman's Associate program and the lesson's learned from multiple simulation experiments and field testing of crew stations (Fig. 5). The stations have a center-mounted yoke that allows the user to access all combat-critical functions without taking their hands off of the yoke. Three color flat panel displays allow control of and access to all vehicle systems. A suite of mechanical switches are used to control guarded functions, such as master power or weapon arming, and are used to configure the information presented on the flat panel displays. In addition to the displays and yoke, the stations have speech recognition capabilities and will have three-dimensional audio.



Figure 0. Crewman's Associate Simulator



Figure 0. VTT Cockpit

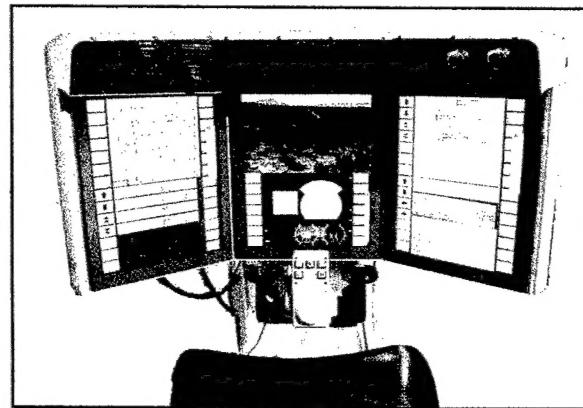


Figure 0. CAT Cockpit

The primary screens are built from 20.1" displays manufactured by Sharp and operated in portrait mode. They have the following characteristics:

- 1600 x 1200 pixels resolution
- +/- 85° viewing angle
- 350:1 contrast ratio

The displays have touch screens, allowing soft buttons to be used for non-critical tasks. The interface design restricts the soft buttons to the outer 1.5 inches of the display, leaving an 18" diagonal area for data presentation that will not be smudged through use of the soft buttons (Fig. 6). This area will remain clear for information which require high level of discrimination (e.g. maps).

The displays are split-window capable, allowing a total of six display areas to be available to the operator at any time (Fig. 7). The operator can access screens to control his own vehicle (setup, indirect driving view, driving console, target acquisition, target queue, etc.). He can also access screens designed to help him manage unmanned assets (robotic vehicle control, status, mission planning, reconnaissance, direct fire, and indirect fire). A final set of screens enable command and control activities (incoming and outgoing messages, interactive map control, and battlefield visualization). Each operator is able to configure their screens to meet their current mission tasks according to their preferences. For example, when driving through indirect vision, the upper portion of each display is dedicated to imagery from day and night cameras mounted to the front and rear of the vehicle.

5. EXPERIMENTATION SCHEDULE AND RESULTS

The program's schedule was developed with a focus on providing timely technology and data to the FCS program. The test and experimentation schedule includes yearly engineering field-testing and data collection. Operational experiments, operated by active duty soldiers, were conducted February-March, 2003 and are scheduled for February 2006. These dates align with key FCS program decision points.

The experiments in February and March of 2003 occurred at Ft. Bliss, Texas and included a variety of assets, including the CAT vehicle, the Robotic Follower ATD vehicle, two Experimental Unmanned Vehicles from the Army/Office of the Secretary of Defense (OSD) Demo III program, and several Highly Mobile Multipurpose Wheeled Vehicles (Fig. 8). During the experiments, the CAT cockpit was tested using a crew of two soldiers operating mission scenarios that were designed to contain the highest workload battlefield conditions. Following these operational experiments, critical cockpit technologies underwent detailed engineering evaluation testing to quantify their performance. These components were the indirect vision driving system and the speech recognition system. Data analysis and reporting on all

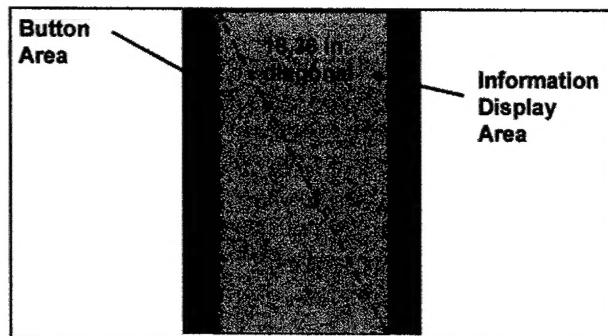


Figure 0. CAT Screen Areas

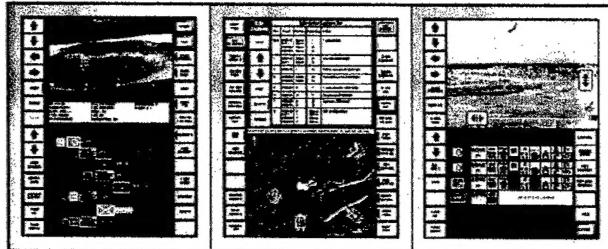


Figure 0. Sample CAT Displays Layout

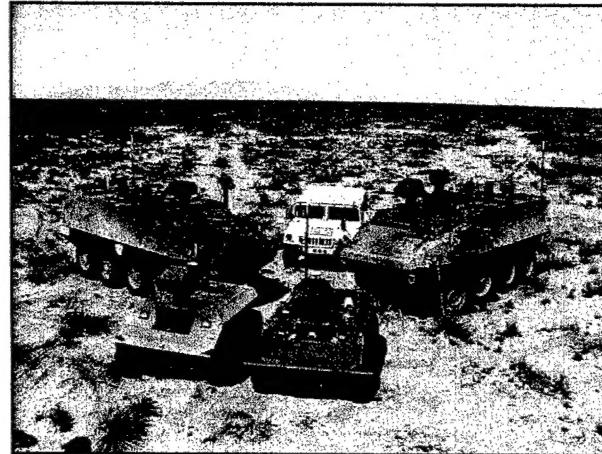


Figure 0. Test Assets at Ft. Bliss

of the Ft. Bliss tests is scheduled to be completed by the end of April, 2003.

By February 2006, additional capabilities will be added to the cockpit for a second round of operational testing at a military test site. These technologies include a throat microphone to improve speech recognition in noise environments, three-dimensional audio, improved display drivers to increase the performance of the video windowing, a driver's aid, an auto-pilot mode, and a commander's associate.

6. SUMMARY

The Crew integration & Automation Testbed ATD is focused on providing advanced interface and automation technologies required for the Future Combat Systems program. The Tank Automotive Research, Development & Engineering Center (TARDEC) is developing, integrating and testing this technology in a C-130 transportable vehicle to demonstrate robust multi-mission capable cockpits for the Future Combat Systems program. The capability is being matured and demonstrated successively in field experiments from 2003 to 2006 and will be an enabling technology for the Army to reach its transformation vision.

7. REFERENCES

¹ Army vision Brochure from <http://www.army.mil/vision/default.htm>, 2003

² Future Combat Systems world wide web site, available at <http://www.darpa.mil/tto/programs/fcs.html>, 2003